CLAIMS

[1] A method of controlling pressure in an electric injection molding machine, comprising:

detecting an angular velocity ω of a motor operative to propel forward a screw in an injection molding machine;

deriving an estimated melt pressure value $\delta\hat{}$, based on an observer, from said detected angular velocity ω of said motor and a torque command value T^{CMD} given to said motor; and

controlling said motor such that said estimated melt pressure value $\delta\hat{}$ follows a melt pressure setting δ^{REF}.

[2] The method of controlling pressure in an electric injection molding machine according to claim 1, wherein said observer is represented by the following Expression 1.

[Expression 1]

$$\frac{d}{dt}\begin{pmatrix}\omega\hat{}\\ \delta\hat{}\end{pmatrix}=\begin{pmatrix}d_1 & 1/J\\ d_2 & 0\end{pmatrix}\begin{pmatrix}\omega\hat{}\\ \delta\hat{}\end{pmatrix}+\begin{pmatrix}1/J\\ 0\end{pmatrix}T^{CMD}+\begin{pmatrix}1/J\\ 0\end{pmatrix}F(\omega)-\begin{pmatrix}d_1\\ d_2\end{pmatrix}\omega$$

where $\omega\hat{}$: Estimated value of Angular velocity of Motor

d_1, d_2: Certain coefficients

J: Inertia moment over Injection mechanism

$F(\omega)$: Dynamic frictional resistance and Static frictional resistance over Injection mechanism

[3] The method of controlling pressure in an electric injection molding machine according to claim 1, wherein said observer is represented by the following Expression 2.

[Expression 2]

$$\omega\hat{}=\omega\hat{}_{-1}+\{d_1(\omega\hat{}_{-1}-\omega)+(1/J)\ (T^{CMD}{}_{-1}+\delta\hat{}_{-1}+F(\omega))\}\,dt$$

$$\delta\hat{}=\delta\hat{}_{-1}+\{d_2(\omega\hat{}_{-1}-\omega)\}\ dt$$

where $\hat{\omega}$: Estimated value of Angular velocity of Motor

d_1, d_2: Certain coefficients

J: Inertia moment over Injection mechanism

F(ω): Dynamic frictional resistance and Static frictional resistance over Injection mechanism

x_{-1}: Value of x at Immediately preceding processing period

[4] The method of controlling pressure in an electric injection molding machine according to claim 1,

wherein said screw in said injection molding machine and said motor are coupled together via a belt suspended around pulleys mounted on respective rotation shafts, and

wherein said observer is represented by the following Expression 3.

[Expression 3]

$$\frac{d}{dt}\begin{pmatrix}\hat{\omega}^M\\ \hat{\omega}^L\\ \hat{F}\\ \hat{\delta}\\ \hat{\sigma}\end{pmatrix}=\begin{pmatrix} d_1 & 0 & -\frac{R^M}{J^M} & 0 & 0\\ d_2 & 0 & \frac{R^L}{J^L} & \frac{1}{J^L} & 0\\ d_3+K_bR^M & -K_bR^L & 0 & 0 & 0\\ d_4 & K_w & \frac{K_{wd}R^L}{J^L} & \frac{K_{wd}}{J^L} & 1\\ d_5 & 0 & 0 & 0 & 0\end{pmatrix}\begin{pmatrix}\hat{\omega}^M\\ \hat{\omega}^L\\ \hat{F}\\ \hat{\delta}\\ \hat{\sigma}\end{pmatrix}+\begin{pmatrix}\frac{1}{J^M}\\ 0\\ 0\\ 0\\ 0\end{pmatrix}T^{CMD}+\begin{pmatrix}0\\ \frac{1}{J^L}\\ 0\\ \frac{K_{wd}}{J^L}\\ 0\end{pmatrix}F_d(\omega^L)-\begin{pmatrix}d_1\\ d_2\\ d_3\\ d_4\\ d_5\end{pmatrix}\omega^M$$

where d_1-d_5: Certain coefficients

J^M: Inertia moment at Motor side

ω^M: Angular velocity of Motor

R^M: Pulley radius at Motor side

F: Tension of Belt

K_b: Spring constant of Belt

J^L: Inertia moment at Screw side

ω^L: Angular velocity at Screw side

R^L: Pulley radius at Screw side

$F_d(\omega^L)$: Dynamic frictional resistance at Screw side

K_w: Elastic modulus of Resin

K_{wd}: Coefficient of Viscosity of Resin

σ: Force of Screw pushing Resin

[5] The method of controlling pressure in an electric injection molding machine according to claim 1,

wherein said screw in said injection molding machine and said motor are coupled together via a belt suspended around pulleys mounted on respective rotation shafts, and

wherein said observer is represented by the following Expression 4.

[Expression 4]

$$\hat{\omega}^M = \hat{\omega}^M{}_{-1} + \left\{d_1\left(\hat{\omega}^M{}_{-1} - \omega^M\right) + \frac{1}{J^M}\left(T^{CMD}{}_{-1} - R^M\hat{F}_{-1}\right)\right\}dt$$

$$\hat{\omega}^L = \hat{\omega}^L{}_{-1} + \left\{d_2\left(\hat{\omega}^M{}_{-1} - \omega^M\right) + \frac{1}{J^L}\left(R^L\hat{F}_{-1} + \hat{\delta}_{-1} + F_d\left(\omega^L\right)\right)\right\}dt$$

$$\hat{F} = \hat{F}_{-1} + \left\{d_3\left(\hat{\omega}^M{}_{-1} - \omega^M\right) + K_b\left(R^M\hat{\omega}^M{}_{-1} - R^L\hat{\omega}^L{}_{-1}\right)\right\}dt$$

$$\hat{\delta} = \hat{\delta}_{-1} + \left\{d_4\left(\hat{\omega}^M{}_{-1} - \omega^M\right) + K_w\hat{\omega}^L{}_{-1} + \frac{K_{wd}}{J^L}\left(R^L\hat{F}_{-1} + \hat{\delta}_{-1} + F_d(\omega^L)\right) + \hat{\sigma}_{-1}\right\}dt$$

$$\hat{\sigma} = \hat{\sigma}_{-1} + d_5\left(\hat{\omega}^M{}_{-1} - \omega^M\right)dt$$

where d_1-d_5: Certain coefficients

J^M: Inertia moment at Motor side

ω^M: Angular velocity of Motor

R^M: Pulley radius at Motor side

F: Tension of Belt

K_b: Spring constant of Belt

J^L: Inertia moment at Screw side

ω^L: Angular velocity at Screw side

R^L: Pulley radius at Screw side

$F_d(\omega^L)$: Dynamic frictional resistance at Screw side

K_w: Elastic modulus of Resin

K_{wd}: Coefficient of Viscosity of Resin

σ: Force of Screw pushing Resin

x_{-1}: Value of x at Immediately preceding processing period

[6] The method of controlling pressure in an electric injection molding machine according to claim 1,

wherein said screw in said injection molding machine and said motor are coupled together via a belt suspended around pulleys mounted on respective rotation shafts, and

wherein said observer is represented by the following Expression 5.

[Expression 5]

$$\frac{d}{dt}\begin{pmatrix}\hat{\omega}^M \\ \hat{\omega}^L \\ \hat{F} \\ \hat{\delta}\end{pmatrix} = \begin{pmatrix} d_1 & 0 & -\frac{R^M}{J^M} & 0 \\ d_2 & 0 & \frac{R^L}{J^L} & \frac{1}{J^L} \\ d_3 + K_b R^M & -K_b R^L & 0 & 0 \\ d_4 & 0 & 0 & 0 \end{pmatrix}\begin{pmatrix}\hat{\omega}^M \\ \hat{\omega}^L \\ \hat{F} \\ \hat{\delta}\end{pmatrix} + \begin{pmatrix}\frac{1}{J^M} \\ 0 \\ 0 \\ 0\end{pmatrix} T^{CMD} + \begin{pmatrix}0 \\ \frac{1}{J^L} \\ 0 \\ 0\end{pmatrix} F_d(\omega^L) - \begin{pmatrix}d_1 \\ d_2 \\ d_3 \\ d_4\end{pmatrix}\omega^M$$

where d_1-d_4: Certain coefficients

J^M: Inertia moment at Motor side

ω^M: Angular velocity of Motor

R^M: Pulley radius at Motor side

F: Tension of Belt

K_b: Spring constant of Belt

J^L: Inertia moment at Screw side

ω^L: Angular velocity at Screw side

R^L: Pulley radius at Screw side

$F_d(\omega^L)$: Dynamic frictional resistance at Screw side

[7] The method of controlling pressure in an electric injection molding machine according to claim 1,

wherein said screw in said injection molding machine and said motor are coupled together via a belt suspended around pulleys mounted on respective rotation shafts, and

wherein said observer is represented by the following Expression 6.

[Expression 6]

$$\hat{\omega}^{M} = \hat{\omega}^{M}{}_{-1} + \left\{ d_1\left(\hat{\omega}^{M}{}_{-1} - \omega^{M}\right) + \frac{1}{J^{M}}\left(T^{CMD}{}_{-1} - R^{M}\hat{F}_{-1}\right)\right\} dt$$

$$\hat{\omega}^{L} = \hat{\omega}^{L}{}_{-1} + \left\{ d_2\left(\hat{\omega}^{M}{}_{-1} - \omega^{M}\right) + \frac{1}{J^{L}}\left(R^{L}\hat{F}_{-1} + \hat{\delta}_{-1} + F_d\left(\omega^{L}\right)\right)\right\} dt$$

$$\hat{F} = \hat{F}_{-1} + \left\{ d_3\left(\hat{\omega}^{M}{}_{-1} - \omega^{M}\right) + K_b\left(R^{M}\hat{\omega}^{M}{}_{-1} - R^{L}\hat{\omega}^{L}{}_{-1}\right)\right\} dt$$

$$\hat{\delta} = \hat{\delta}_{-1} + d_4\left(\hat{\omega}^{M}{}_{-1} - \omega^{M}\right) dt$$

where d_1-d_4: Certain coefficients

J^M: Inertia moment at Motor side

ω^M: Angular velocity of Motor

R^M: Pulley radius at Motor side

F: Tension of Belt

K_b: Spring constant of Belt

J^L: Inertia moment at Screw side

ω^L: Angular velocity at Screw side

R^L: Pulley radius at Screw side

$F_d(\omega^L)$: Dynamic frictional resistance at Screw side

x_{-1}: Value of x at Immediately preceding processing period

[8] The method of controlling pressure in an electric injection molding machine according to claim 3, 5 or 7, further comprising:

calculating said torque command value T^{CMD} for said motor based the following Expression 7; and

feeding back said torque command value to said motor.

[Expression 7]

$$T^{CMD} = kp\,(\delta^{REF} - \hat{\delta}) + \alpha$$

where kp: Certain constant

α: Certain function or constant

[9] An apparatus for controlling pressure in an electric injection molding machine, comprising:

an observer arithmetic unit operative to derive an estimated melt pressure value $\delta\hat{}$, based on an observer, from an angular velocity ω of a motor operative to propel forward a screw in an injection molding machine and a torque command value T^{CMD} given to said motor; and

a torque arithmetic unit operative to calculate said torque command value T^{CMD} for said motor using said estimated melt pressure value $\delta\hat{}$ derived at said observer arithmetic unit and feed back said torque command value to said motor.

[10] The method of controlling pressure in an electric injection molding machine according to claim 1, further comprising deriving a dynamic frictional resistance $F(\omega)$from a relation between a velocity or position and a torque or current value associated with said motor at the time of injection with no resin loaded.

[11] The method of controlling pressure in an electric injection molding machine according to claim 1, further comprising:

defining a dynamic frictional resistance $F(\omega)$ as a sum of a velocity-dependent component and a load-dependent component;

deriving said velocity-dependent component of said dynamic frictional resistance from a relation between a velocity or position and a torque or current value associated with said motor at the time of injection with no resin loaded; and

deriving said load-dependent component of said dynamic frictional resistance from a relation between a

torque or current value and a pressure value at the time of injection with a plugged nozzle.